March 1, 1928.

PROGRAM AND PLAN

OF

EUROPEAN CORN BORER INVESTIGATIONS

1928.

Assignments to Laboratories

or Groups.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

March 1, 1928.

TENTATIVE PROGRAM AND PLAN FOR CORN BORER INVESTIGATIONS AT ARLINGTON, MASSACHUSETTS (1928)

I - Control.
  A - Plowing infested material.
    1 - Field observations.
      a - Check effectiveness of fall and spring plowing, under farm conditions, following standard methods of debris examination. Special stress upon fields where larval population was determined in standing stalks or stubble before treatment. Compute percentage of control achieved, based upon larval population before and after treatment.
      b - Special observations upon status of weeds, grasses, trash, etc., along fence-row or field margin, of fields where infested cornstalks were plowed under.
  B - Clean-up operations.
    1 - Check results of general clean-up operations, including burning, feeding to livestock, etc.
  C - Seasonal and varietal planting.
    1 - Experimental plots of sweet, dent and flint corn at Waltham.
      a - Standard varieties for the region planted on successive dates. Detailed observations same as in former years.
    2 - Surveys of commercial fields, with relation to effect of time of planting and selection of varieties - as formerly.
    3 - Analysis of applicable data secured during progress of annual infestation survey (from II-A-B and E)
    4 - Continue phenological studies on the development of selected trees or shrubs, to correlate plant development with optimum time of planting to avoid severe injury, and with seasonal occurrence of the insect.
      a - Same details recorded as formerly.
  D - Host plants (with special reference to control, quarantine and scouting data).
    1 - Continuation of host plant investigations.
      a - List of host plants kept up to date.
      b - Additional investigations relative to stages of insect occurring on known host plants.
      c - Critical determination of status of principal host plants as true food plants or as shelter plants.
      d - Continued investigations relating to suspected host plants.
      e - Continued study of plants exhibiting toxic or repellant qualities to the corn borer.
    2 - Continuation of isolation cages containing certain host plants infested by P. nubilalis, to determine ultimate effect of host plants, other than corn, on the insect and whether host plant races exist.
  E - Trap crops.
    1 - Analysis of annual infestation surveys as in previous years.

- a - Beets, dahlias, hemp, Polygonum, Xanthium, Ambrosia, Artemisia

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ITEM NO.	DESCRIPTION OF PACKAGE	DESCRIPTION OF CONTENTS	DATES COVERED	
			From—	To—

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2 - Special observations on selected farms where corn is planted on progressive dates.

F - Possible adaptation to insecticides.

1 - Critical study of feeding habits of young larvae on corn plants, i.e.; - extent of feeding on leaf-blades, tassel buds, etc., and proportion of larvae feeding on exterior of plant.

II - Dispersion (Same details as in previous years)

A - Similar corn surveys of cornfields in same townships as in original survey, in New England, eastern N. Y. and Long Island.

B - Similar surveys in cornfields of new townships along outside border of the older area.

C - Scouting for infestation in townships not previously recorded as infested.

D - Classification of area into zones according to character and intensity of infestation.

E - Special early season survey in sweet corn fields.

F - Special surveys of corn and weed areas in different representative types of terrain - i.e., river valleys, hill district and coastal plain.

G - Continuation of similar comparative surveys in important economic host plants other than corn. (beans, beets, celery, dahlias, chrysanthemums).

H - Continuation of special project to determine loss in yield of corn caused by indirect injury.

1 - Reduction in number of ears.
2 - do. weight do. and grain.
3 - do. quality do. do.

III - Mortality.

A - Continuation of larval establishment studies.

1 - Determine proportion of eggs which develop into mature larvae (each generation) in different representative localities and on different types of corn.

2 - Same on important plants other than corn. (economic)

3 - Same for important and susceptible weed hosts.

B- Winter mortality. (same details as formerly)

IV - Seasonal Occurrence and Season cycle.

A - Gross records of seasonal occurrence, reduced to a minimum, to secure same data as detailed in former programs.

B - Generation occurrence.

1 - Special stress upon field investigations, to determine percentage of individuals developing a second generation.

C - Phenological studies as mentioned under I-c-5.

D - Continuation of investigations relating to influences contributing to separation of different seasonal cycle zones (one and two generations).

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1 - Material transferred from various areas and isolated in large field cages at Waltham.
  a - From western New York (1 gen.)
  b - From France (2 gen.)
  c - From Italy (2 gen.)
  d - From Hungary (1 gen.)
2 - Cross-breeding and rearing of
  a - Mass. female - New York males.
  b - " males - " " females.

V - Natural enemies.
A - Parasites (investigations in U. S.)
1 - Importation of parasites from Europe as in the past.
  a - Storing of material as received from abroad.
  b - Emergence and careful mating of adult parasites from above material.
    (1) - Special precautions to prevent escape of hyper-parasites.
  c - Liberation of parasite adults not required for breeding projects.
    (1) - New England (2) - New York (5) - Michigan
    (3) - Pennsylvania (4) - Ohio (6) - Indiana.
  d - Allot quota of parasite material to co-operators at Canadian Parasite Laboratory at Chatham, Ontario - following same procedure as in the past.
2 - Laboratory breeding of parasite adults for liberation, using imported adults as breeding stock.
  a - Special campaign to produce large numbers of Apanteles sp. and Microgaster tibialis. Rearing technique now developed for these two species.
3 - Development of rearing technique for six additional species of introduced parasites, through a critical study of their biology.
4 - Large scale rearing project with such species as a satisfactory technique is developed.
5 - Continuation of project for recovery of imported species.
  a - Bulk collections of infested cornstalks placed in large screened cages. Includes large parasite conservation cages.
  b - Collections of host larvae, to be isolated for more accurate knowledge of percentage of parasitism, host relationship, velocity and direction of dispersion, etc.
6 - Native parasites.
  a - Laboratory breeding of Trichogramma minutum.
    (1) - Test value of field liberations, followed by systematic collections.
    (2) - Determine costs and economic possibilities of annual liberations as supplementary a control measure.
  b - Continue observations and comparisons re native species.
    (1) - Special collection of host eggs to determine effectiveness of T. minutum.

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(2) - Study of morphological characters to aid in their identification and separation from imported European species.
(3) - Photographic studies, following recently perfected methods.
(4) - Preparation for reference to group specialists in National Museum or elsewhere.

d - Continuation studies of native, or introduced parasites, attacking other boring insects which are, or may later, become parasitic upon corn borer. To aid in the identification and separation of various developmental stages of parasites found attacking P. nubilalis.

e - Continuation of critical studies re the status and abundance of native parasites recovered from large Parasite Conservation cages, with proper allowance for their assignment to the proper host, as determined by isolated, individual rearings. Special attention to comparative status of each native species from year to year, as a natural enemy of P. nubilalis.

B - Parasites (Investigations In the Orient)

1 - Continuation of the investigations in co-operation with the Japanese Beetle Laboratory with same general procedure as outlined for European parasitic material.

a - Biological observations.
b - Economic "
c - Ecological "
d - Parasitic "

(1) - Shipment to the U. S. of those species which investigation may demonstrate as suitable for trial in this country.

C - Predators.

1 - Continuation of studies to determine status and effectiveness of various predators as enemies of the insect.

a - Insects (especially Pentatomids)
b - Spiders
c - Birds
d - Animals

VI - Insecticide investigations.

A - Experimental tests.

1 - Materials.

a - Arsenicals (example)

(1) - Hydrogen lead arsenate.
(2) - Coated " "
(3) - Colloidal " "
(4) - Basic " "
(5) - Calcium arsenate
(6) - Etc.

b - Emulsified extracts and water solutions (examples).

(1) - Pyrethrum.
(2) - Derris.
(3) - Pyridine

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(4) - etc.

c - Oil emulsions (examples)
(1) - Paraffin oils.
(2) - Fishoils.
(3) - Etc.

d - Silico-fluorides (examples)
(1) - Sodium silico-fluoride
(2) - Potassium " "
(3) - Calcium " "
(4) - Aluminum " "
(5) - Etc.

e - Tobacco dust

f - Carriers, emulsifiers, adhesives, colloids, etc., employed in preparation and application of insecticidal materials.

2 - Tested for.
a - Toxicity
b - Adhesiveness.
c - Number applications required.
d - Plant tolerance.
e - Compatible combinations.
f - Cost of applications:-
(1) - For small areas.
(2) - Large scale.

3 - Application
a - Plots:-
(1) Tolerance test plots.
(2) Toxicity " "
(3) Commercial field test plots.
(4) Alternate check plots.
(5) Plots in triplicate and distributed over field.

b - Methods:-
(1) - Compressed-air sprayers.
(2) - Rotary fan dusters.
(3) - Bellows dusters.
(4) - Power sprayer.
(5) - Power duster
(6) - Air plane dusting

c - Supplementary adhesives.
(1) - Casein.
(2) - Fish oil soap.
(3) - Paraffin oil emulsions.

4 - Schedule of applications.
a - Number applications necessary.
b - Application with reference to seasonal development of:-
(1) - Corn plant.
(2) - European corn-borer.
c - Relation of application to climatic conditions.

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ITEM NO.	DESCRIPTION OF PACKAGE	DESCRIPTION OF CONTENTS	DATES COVERED	
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B - Laboratory investigations:-
  1 - Chemical tests
    a - Exact formulae of material employed.
    b - Deterioration:-
      (1) - In storage.
      (2) - On host plant
    c - Residues.
      (1) - Retention of lethal capacity.
      (2) - Toxicity to human species.
      (3) - Toxicity to domestic stock.
    d - Compatible combinations.
    e - Value of emulsifying agents.
    f - Cause of intolerance.
  2 - Biological tests.
    a - Ovicidal value.
    b - Larvicidal capacity.
      (1) - Specific effect.
      (2) - Rapidity of action.
      (3) - Quantity required.
      (4) - Mortality.
  3 - Relation of insecticides to feeding habits.
    a - Distribution of insecticide.
    b - Distribution of feeding punctures.
    c - Materials ingested.
    d - Materials rejected.
    e - Age of larva at first ingestion of plant material.
    f - Physiology of digestion in 1st instar larvae.
    g - Importance of cannibalism in feeding habits.
    h - Nature of tropic-response complex governing feeding reaction.
      (1) - Hygro-thermal stimulus.
      (2) - Phototropic stimulus.
      (3) - Chemotropic stimulus,
      (4) - Thigmotropic stimulus.
      (5) - Geotropic stimulus.
    i - Operation of response complex in relation to presence of insecticides.
    j - Relation of insecticidal agents to tunneling habit.
C - Trial field tests.
  1 - Efficiency with respect to plant tolerance.
  2 - Efficiency with respect to cost of application.
D - Commercial field tests.
  1 - Efficiency of method and material.
  2 - Cost of method and material.
  3 - Profit under commercial conditions.
  4 - Relation of insecticides to respiratory requirements.
    a - Distribution of insecticide.
    b - Source of metabolic oxygen.
    c - Method of oxygen absorption.
    d - Specific effect of "contact insecticides".

E - Field tests of the more promising materials at Toledo, Ohio Demonstration and Development Farm.
F - Collaborative insecticide program with various interested state workers, Dominion of Canada and Province of Ontario.

VII - Tropic response (co-operation) with Boyce-Thompson Institute).
A - Chemotropic response in adult female.
1 - Value of attrahent substances.
a - Production of volatile extractive constituents of corn, hops, etc.
(1) - Extraction at Boyce-Thompson Institute.
(2) - Sealed, numbered and shipped.
b - Chemotropic tests at Arlington.
(1) - Tested for attrahent value.
(2) - Modified olfactometer employed under controlled conditions.
(3) - Field tests employing traps.
c - Relation of attrahent capacity to practicable application.
2 - Value of repellant substances.
a - Production.
b - Chemotropic tests.
c - Relation to practicable application.
B - Relation of chemotropism to the normal response complex of the European corn borer.
1 - Investigation of the identity of the chemotropic response
a - Separation of a feeding response.
b - Separation of a flight response.
c - Separation of a mating response.
d - Separation of an oviposition response.
2 - Investigation of the response complex causing the induction of chemotropism.
a - Influence of the oviposition response on the development of chemotropism.
b - Influence of chemotropism on the development of an oviposition reaction.
c - Same study of other angles of this problem.
3 - Influence of a tropic reaction on the development of a chemotropic threshold.
a - Effect of a phototropic reaction on chemotropic response
b - Same type of study of other tropisms.
c - Sequence of reactions initiating a chemotropic response.
d - The ecological complex in which chemotropism is most acute.

C - Field investigations of attrahent and repellant substances.
1 - Physical state of materials.
a - As a voltalizing concentrated liquid.
b - Diluted.
(1) - Tests of diluents, solvents, and adsorptives.
(2) - Supplemental carriers and adhesives.

c - Emulsified.
d - Influence and exploitation thermal and hygrostatic air conditions.
2 - Field trap experiments attrahent baits.
a - Effect of an ecological complex on the efficiency of a trap.
b - Coefficient of correlation for bait-trap field work
c - Correlation of chemotropism and infestation of planted corn.
d - Relation of rate of infestation of crops to various environmental factors by making use of baited traps.
e - Investigation of corn-borer population with reference to climatic and ecological complexion of the area.
D - Tropic response in the larval instars.
1 - Laboratory experiments.
a - Identification of tropic reactions.
b - Sequence of tropic reactions.
c - Influence of response complex phenomena on tropic reactions.
d - Measurement of repellant and attrahent values in response phenomena.
2 - Field experiments.
a - Relation of response to planting method.
b - Relation of response to insecticide application.

VIII - Miscellaneous.
A - Photography.
1 - Apparatus and experimental equipment, etc.
2 - Drawings, maps, charts, etc.
3 - Infested plants, typical injury, life-stages, etc.
4 - Parasites and technique employed.
5 - Associated insects and their typical phases.
6 - Photomecrography
B - Taxonomy and Exhibition.
1 - Preparation and preservation of material for exhibition or study.
2 - All stages of corn borer and associated insects.
3 - Typical samples illustrating injury to host plants.
4 - Preparation of Riker Mounts, etc., for exhibition and illustration.
5 - Arrangement and care of working collection.
C - Statistics.
1 - Crop losses.
a - Corn and other economic crops
D - Identification, assembling and filing of material sent in by field scouts and quarantine inspectors.

TENTATIVE PROGRAM AND PLAN FOR EUROPEAN CORN BORER INVESTIGATIONS IN CENTRAL EUROPE (1928)

A - Distribution.

1 - Continued checking of recorded distribution in Hungary, Yugoslavia, Roumania, Poland, Czechoslovakia, and Germany with extended scouting and study in Roumania and Poland may be limited to scouting in northern Poland and into Lithuania and Esthonia. Preliminary scouting of important areas in Russia, if arrangements can be made to that end.

B - Seasonal History.

1-Continued collection of data in Hungary, Yugoslavia, Roumania, Czecho-slovakia, Germany and Poland. The most detailed information will be collected in Hungary and Yugoslavia.

a - Seasonal history data will be collected in Hungary and Yugoslavia during the course of the field work from May until October, throughout the main corn growing regions. The progress of pupation and emergence will be determined during the course of dissecting the cornstalks of 1927. Egg counts will be started in the field as soon as possible and continued throughout the period of oviposition, and frequent observations will be made to determine the actual length of time that eggs may be found in the field. From the time that larvae are available in the field, systematic collections will be made of all the specimens found, thus offering a means for not only determining the percentage of individuals in each stage but also the percentage of parasitism. Special collections and studies in selected towns of Danube Basin.

b - Data will also be collected to show the transitions zones between areas of one and two-generation seasonal history.

1 - An attempt will be made to secure information from the merging of the two-generation area of the Dalmatian Coast into the one-generation area of Yugoslavia. If time is available, the merging of the two areas will also be studied in the vicinity of Skoplje to Nis, Yugoslavia.

2 - In any area visited particular attention will be paid to the collection of such information as might lead to the knowledge concerning the reactions of the insect to certain distinct types of environment.

C - Abundance and Damage. (continuation of preceding 4-year period)

1 - A thorough study of this point will be continued throughout the central European plains at points covering significant ecological conditions.

a - The collection of this data will include all those points mentioned in the main plan of work.

b - Data upon the infestation in other economic crops than corn.

c - Similar observations will be made to determine the infestation in such plants as related to heavily infested corn.

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d - Observations to be made upon the infestation in weeds following a similar plan.

D - The determination of economic and non-economic host plants.

E - Parasites. (continuation of preceding 4-year period)

1 - The effectiveness of the different species of parasites will be studied by means of the various dissections made during the course of the field work. To follow plans already made and carried out during the past four seasons' investigations.

F - Natural enemies other than parasites.

G - Control. (continuation of preceding 4-year period)

1 - The effectiveness of control measures, particularly clean-up, measured by an examination of the debris remaining in fields after crops have been harvested and prepared for new sowings. Procedure same as in U. S.

2 - A study of other control measures practiced.

a - Analyze the effectiveness of the various planting dates from collected field data.

b - Same procedure for other economic crops.

H- The collection of meteorological records with special emphasis upon those needed for the proper interpretation and correlation of biological data. (continuation of preceding 4-year period)

I - Continue the collection of agricultural records with special emphasis upon those relating to cultural methods, crop rotations, phenology, associated insects, etc., needed for the proper interpretation of the important facts concerning the insect. In addition to these enumerated points it is hoped to continue the investigation of the possibility of substituting various species of sorghums for corn, as a fodder plant, in regions of heavy infestation. Plantings of five important species of sorghums, selected by the Arlington Laboratory, will be planted in each of five selected localities in the central European plains to determine the susceptibility of these plants to the attack of the insect. This cultural experiment should be continued for at least five years.

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TENTATIVE PROGRAM AND PLAN FOR CORN BORER INVESTIGATIONS AT SILVER CREEK, N. Y. (1928)

I - Control.
- A - Plowing infested material.
  - 1 - Field observations.
    - a - Check effectiveness of fall and spring plowing, under farm conditions, following same method of debris examination as in previous years. Especial stress upon fields where larval population was determined in standing stalks or stubble before treatment.
    - b - Special observations upon status of weeds, grasses, trash, etc., along fence-row or field margin, of fields where infested cornstalks were plowed under.
- B - Burning infested material.
  - 1 - Check effectiveness of burning, under farm conditions, using standard debris examinations as in previous years.
- C - Standard debris examination extended to include plant debris on surface of fields subjected to control practices other than those mentioned previously (i.e., poled, raked, burned and disked; poled, raked, burned and plowed; stubble fields disked without previous treatment; stubble fields plowed without previous treatment; stalks plowed without previous treatment, etc.).
- D - Observations made in fence rows and weed areas near infested cornfields to determine the degree of infestation which may occur through migration, or other means. These examinations are made in representative areas selected from each fence row or weed area.
- E - Observations made on land lying outside clean-up area compared to similar observations made on land within the clean-up area to obtain, if possible, information concerning the value of compulsory clean-up.
- F - Check effectiveness of special field machinery.
  - 1 - Stubble pulverizer.
  - 2 - Burning machine.
  - 3 - Low cutting, etc.
- G - Seasonal and varietal planting.
  - 1 - Analysis of time of planting and selection of types, varieties or strains of corn, as shown by data secured in annual infestation surveys of commercial fields. Same method as in previous years (taken from II - A).
  - 2 - Continue phenological studies on the development of common trees or shrubs, to correlate plant development with optimum time of planting to avoid severe injury, and with seasonal occurrence of the insect, irrespective of calendar dates.
    - a - Same plants and phases as in 1927.
- H - Host plants (with special reference to control, quarantine and scouting data).

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1 - Continue studies of economic plants other than corn, listed as hosts in other single generation areas. Note per cent plants infested, larval population, distance from growing corn and from infested corn refuse of preceding year. Also probable status of plant as true host or shelter plant.
2 - Same as above in susceptible weeds and large stemmed grasses.
3 - Continue list of host plants.
a - Designate probable status of each, as a true host or as a shelter plant.
b - Indicate status of infestation in each, as in F - 1.
c - For new host plants, secure authentic determination of plant and insect.

I - Disposal of infested material in manure pile or barnyard.
1 - Continuation of experiments in animal manure started in fall of 1926, and check on experiments conducted in spring of 1926.

J - Storage of cornstalks (simulating farm storage for fodder)
1 - Experimental studies as in previous years.
a - Separate lots of infested cornstalks stored under shelter at intervals, from late Autumn to late Spring, under various conditions, i.e. - warm dry, cold dry, cold moist, warm moist, etc., in structures excluding precipitation and in structures partly open to the weather.
(1) - Screen each lot, or standard portion thereof, for emergence of adults. Record dates of adult emergence as well as temperature and humidity conditions in storage quarters.
2 - Field observations. Check D - 1 by examination of stalks, corn cobs, ear corn, etc., stored under various conditions on farms.

K - Trap crops. (incidental as in previous years) through an analysis of data in annual infestation surveys.

II - Infestation surveys in corn (same as formerly)
A - Similar comparative infestation surveys to 1927, in original area of infestation.
B - Comparative infestation in field and sweet corn, in relation to seasonal planting (an analysis of data under II - A).
C - State wide survey in late summer and early autumn. Same plan as in 1927, with details decided prior to survey.
D - State-wide survey of fields containing cornstalks and stubble during the late autumn to determine, if possible, the larval population of representative fields before clean-up. This information to be used in connection with (determining effectiveness) of clean-up work.

III -Seasonal occurrence and seasonal cycle.
A - Gross records of seasonal occurrence, reduced to a minimum, to secure same data as in preceding years.

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B - Generation occurrence. Special observations, as formerly, to determine possible development of second generation in the field.

C - Continuation of project regarding transfer cages of Arlington material. Special effort to keep these experiments up-to-date and to determine possible tendency of two-generation material to revert to a single generation.

IV - Parasites.

A - Rearing of all parasites, native or introduced, which may develop from collected material, or from incidental collections in the field.

B - Mating and liberation of foreign parasites sent from Arlington or elsewhere.

C - Collections for recovery of introduced species.

1 - Large collection cages in western New York and in northwestern Pennsylvania includes large Conservation cages.

2 - Small collections of larvae near colony sites, to be isolated for more accurate knowledge of percentage of parasitism, velocity and direction of dispersion. Record place of collection with reference to point of original liberation.

V - Miscellaneous.

A - Records of winter mortality in the field, under various conditions of exposure. Taken incidentally during the progress of other field work. Specify condition and position of host plant. Note; We need more records on this point from the Silver Creek area.

B- Identification of material sent in by field scouts and quarantine inspectors.

C - Special stress on photos illustrating field conditions, field experiments, machinery operations, etc., etc.

D - Continuation of project to determine percentage of establishment of newly hatched larvae, and factors effecting such establishment.

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TENTATIVE PROGRAM AND PLAN FOR CORN BORER INVESTIGATIONS AT SANDUSKY, OHIO (1928)

I - Control.
  A - Plowing infested material.
    1 - Experimental studies.
      a - Continuation of project to determine influences inducing larvae to desert plowed under host plants.
      b - Comparative mortality, to adult emergence, in trash on soil surface in small area simulating various cultural conditions. No. of larvae in trash computed carefully in each lot. (as in previous years).
        (1) - Area where trash is shaded by growing oats.
        (2) - " " " " " " corn.
        (3) - " kept free of vegetation.
          (a) - Temperature readings on soil surface and within pieces of trash during periods of high temperature and dessicating winds.
      c - Emergence of adults from larvae placed on soil surface on cleanly plowed area. (continuation of preceding years).
        (1) - Cage erected over one-half of area just prior to emergence of adults. Remaining portion of area serves as a check to determine possible presence of living larvae on soil surface.
    2 - Field observations.
      a - Check effectiveness of fall and spring plowing, under farm conditions, following same method of debris examination as in previous years. Especial stress upon fields where larval population was determined in standing stalks or stubble before treatment.
      b - Special observations upon status of weeds, grasses, trash, etc., along fence row or field margin, of fields where infested cornstalks were plowed under.
        (1) - Percentage of larval migration to a definite lineal feet of cornstalks, placed along field border of a heavily infested sweet corn field, plowed under in late summer.
  B - Burning infested material.
    1 - Check effectiveness of burning, under farm conditions, using standard debris examination as in previous years.
  C - Seasonal and varietal planting.
    1 - Analysis of time of planting and selection of types, varieties of strains of corn, as shown by data secured in annual infestation surveys of commercial fields. Same method as in previous years (taken from II-A).
    2 - Continue phenological studies on the development of common trees or shrubs, to correlate plant development with optimum time of planting to avoid severe injury, and with seasonal occurrence of the insect, irrespective of calendar dates.
      a - Same plants and phases as in 1927.
  D - Host plants (with special reference to control, quarantine and scouting data).
    1 - Continue studies of economic plants other than corn, listed

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as hosts in other single generation areas. Note per cent plants infested, larval population, distance from growing corn and from infested corn refuse of preceding year. Also probable status of plant as true host or shelter plant.

2 - Same as above in susceptible weeds, and large-stemmed grasses.

3 - Continue list of host plants.

a - Designate probable status of each, as a true host or as a shelter plant.

b - Indicate status of infestation in each, as in E - 1.

c - For new host plants secure authentic determination of plant and insect.

E - Disposal of infested material in manure pile or barnyard.

1 - Continuation of experience in animal manure, started in fall of 1927, and check on experiments conducted in spring of 1927.

F - Storage of cornstalks (simulating farm storage for fodder.)

1 - Experimental studies as in previous years.

a - Separate lots of infested cornstalks stored under shelter at intervals from late Autumn to late Spring, under various conditions, i.e., warm dry, cold dry, warm moist, cold moist, in structures excluding precipitation and in structures partly open to the weather.

(1) - Screen each lot, or standard portion thereof, for emergence of adults. Record dates of adult emergence.

(2) - Late emerging adults confined in cages to note fecundity and seasonal development of progeny.

b - Continuation of observations upon infested cornstalks, baled and stored under various conditions.

2 - Field observations. Check above by examination of stalks, corncobs, ear corn, etc., stored under various conditions on farms.

G - Trap crops (incidental as in previous years) through an analysis of data in annual infestation surveys.

H - Standard debris examinations extended to include plant debris on surface of fields subjected to various control practices, (i.e., plowed; poled, raked, burned and disked; poled, raked, burned and plowed; disked to small grains or other crops without previous treatment, etc.). Particularly in fields where larval population was determined in autumn of 1927.

II - Infestation surveys in corn (same as previous years)

A - Similar comparative infestation surveys to 1927, in original area of infestation.

B - Comparative infestation in field and sweet corn, in relation to Seasonal planting. (an analysis of data under II-A)

C - State wide survey in late summer and early autumn. Same plan as in 1927, with details decided prior to survey.

D - Continuation of statistical studies pertaining to distribution of larvae in individual fields; to determine adequate samples for infestation surveys and the probable errors involved. Also the relationship between per cent of infestation, or larval population, and actual commercial loss. Involves a statistical study of indirect loss.

UNITED STATES DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY,

WASHINGTON, D. C.

CEREAL AND FORAGE INSECT INVESTIGATIONS.

III - Habits.

A-Continuation of project to determine percentage of establishment of newly hatched larvae, and factors affecting such establishment.

1 - Detailed observations upon egg clusters deposited on different types and varieties of corn under field conditions. Same details as in 1927.

2 - Repeat observations re rate of establishment of larvae on late planted corn.

3 - Relative mortality of young larvae hatching from eggs naturally deposited on Leaming field corn planted May 8, 15, 22, 29; and June 5 and June 12.

4 - Relative mortality of young larvae hatching from eggs naturally laid on Leaming field corn planted in rows, 42", 60", 72" and 84" apart. (Note: It has been observed that few young larvae migrate to the second row of corn, and it is believed possible to materially lessen borer population by interplanting corn with various immune crops, such as soy beans).

5 - Relative selection for oviposition of different types and varieties of field and sweet corn, planted on same date.

6 - Relative selection for oviposition on Leaming field corn planted on different dates

a - Secure heights of corn on definite dates.

B - Continuation of observations upon migration of newly hatched larvae.

C - Determine distance of dispersion of young larvae by wind action, providing preliminary tests give significant indications.

IV - Parasites and Predators.

A - Rearing of all parasites, native or introduced, which may develop from collected material, or from incidental collections in the field.

B - Mating and liberation of foreign parasites sent from Arlington or elsewhere.

C - Collections for recovery of introduced species.

1 - Large collection cages in northeastern, northcentral and northwestern Ohio.

2 - Small collections of larvae near colony sites, to be isolated for more accurate knowledge of percentage of parasitism, velocity and direction of parasite dispersion. Record place of collection with reference to original liberation.

D - Incidental observations upon predators encountered.

V - Seasonal occurrence and seasonal cycle.

A - Gross records of seasonal occurrence, reduced to minimum, to secure same data as in preceding years.

B - Generation occurrence. Special observations, as formerly, to determine possible development of second generation in

the field.

VI - Assemble following data re Life History - based upon field and laboratory observations.
  1 - Duration of adult period.
    a - Total eggs in laboratory
    b - Average eggs per cluster in field

VII - Miscellaneous.
  A - Records of winter mortality in field under various conditions of exposure. Taken incidentally during progress of other work. Specify condition and position of host plant.
  B - Stalk and stubble infestation survey as in 1927 to be made in autumn of 1928.
  c - Identification of material sent in by field scouts and quarantine inspectors.
  D - Special stress on photos illustrating field conditions field experiments, machinery operations, etc., etc.
  E - Continuation of studies to determine the duration of the period of disintergration of cornstalks when plowed under in sandy or heavy soils (Four series - one each to be dug up in autumn of 1928, spring of 1929, autumn of 1929 and spring of 1930.)

TENTATIVE PROGRAM AND PLAN FOR CORN BORER INVESTIGATIONS AT MONROE, MICHIGAN (1928)

I - Control.
- A - Plowing infested material.
  - 1 - Field Observations.
    - a - Check effectiveness of fall and spring plowing, under farm conditions, following standard method of debris examination. Special stress upon fields where larval population was determined in standing stalks or stubble before treatment. Compute percentage of control achieved, based upon larval population before and after treatment.
    - b - Special observations upon status of weeds, grasses, trash, etc., along fence-row or field margin, of fields where infested cornstalks were plowed under.
- B - Burning infested material.
  - 1 - Check effectiveness of burning, under farm conditions, using standard debris examination.
- C - Check effectiveness of various other methods of mechanical control, (i.e. - poled, raked, burned and disked; poled, raked, burned and plowed; stubble fields disked without previous treatment; standing stalks plowed with, or without, previous treatment; stubble fields plowed with, or without, previous treatment, etc.) as in preceding years.
  - 1 - Compute larval population per acre, by standard debris examination. Special stress upon fields where larval population was determined before treatment. Compute percentage of control achieved, based upon larval population per acre before and after treatment.
- D - Check effectiveness of special field machinery.
  - 1 - Stubble pulverizer.
  - 2 - Burning machines.
  - 3 - Low cutting devices.
  - 4 - Husker-shredders, etc.,
- E - Seasonal and varietal planting.
  - 1 - Analysis of effect of time of planting and selection of types, varieties or strains of corn, as shown by data secured in annual infestation surveys of commercial fields. Same method as in previous years. (Taken from II-A).
  - 2 - Continue phenological studies on the development of common trees or shrubs, to correlate plant development with optimum time of planting to avoid severe injury, and with seasonal occurrence of the insect, irrespective of calendar dates.
    - a - Same details as recorded in "Plan for 1926".

F - Host Plants (with special reference to control, quarantine and scouting data).
  1 - Continuation of studies indicated in previous programs. Particular reference to economic plants, other than corn, listed as hosts in other single generation areas. Note per cent plants infested, larval population, distance from growing corn and from infested corn refuse of preceding year. Also the probable status of the plant as a true host or shelter plant.
    a - Special stress on such plants when associated with corn.
  2 - Same as above in susceptible weeds and large-stemmed grasses.
  3 - Continue list of host plants.
    a - Designate probable status of each, as a true host or as a shelter plant.
    b - Indicate data on infestation in each, as in F - 1.
    c - For new host plants, secure authentic determination of plant and insect.
  4 - Isolate in cages the following plants; millet, grain sorghums, beets, Xanthium, Polygonum and attempt to rear P. nubilalis thereon for a succession of generations. Use progeny from original cage from year to year.
G - Small scale tests of various insecticides.
  1 - Critical study of feeding habits of young larvae, i.e. extent of feeding on leaf-blades, tassel buds, etc., and proportion of larvae feeding on exterior of plant.
  2 - Effect of arsenicals on newly hatched larvae and larvae in later stages.
    a - Critical observations to determine whether larvae entering stalk (or other portion of plant), ingest plant tissue at point of entrance.
H - Trap crops.
  1 - Analysis of annual infestation surveys as in previous years.
  2 - Special observations on selected farms, where corn is planted on progressive dates.

II - Infestation surveys in corn (Same details as in previous programs).
  A - Similar comparative survey on same farms and in the same townships as in 1927 and previous years.
  B - Comparative infestation in field and sweet corn, in relation to seasonal planting (an analysis of data under II-A).
  C - State-wide survey in late summer and early autumn. Same as in "Plan for 1927" with details decided prior to survey.

III- Seasonal occurrence and seasonal cycle.
  A - Gross records of seasonal occurrence, reduced to a minimum, to secure same data as detailed in previous programs.
  B - Generation occurrence - Same details as enumerated in previous programs to determine possible development of second generation.

IV - Parasites and predators.

A - Rearing of all parasites, native or introduced, which may develop from collected material, or from incidental collections in the field.

B - Mating and liberation of foreign parasites sent from Arlington or elsewhere. Points of liberation in Michigan same as in 1927.

C - Special project for the continuation of rearing Microbracon and Exeristes as in 1927. Points of liberation in Michigan, Ohio and Indiana same as in 1927.

D - Small scale experiment to determine ability of Microbracon and Exeristes adults to reach soil surface in healthy condition after plowing.

E - Collections for recovery of all introduced species.

1 - Large collection cages in three selected points of Michigan.

2 - Small collections of larvae near colony sites, to be isolated for more accurate knowledge of percentage of parasitism, host relationship, velocity and direction of dispersion, etc. Record point of collection with reference to point of original liberation.

F - Special biological studies of two species of parasites other than Exeristes and Microbracon.

G - Incidental observations upon predators encountered.

V - Miscellaneous.

A - Records of winter mortality in the field, under various conditions of exposure. Taken incidentally during the progress of other field work. Specify condition and position of host plant. Note: We need more records on this point from Michigan.

B - Stalk and stubble infestation survey as in 1927 to be made in autumn of 1928.

C - Identification of material sent in by field scouts and quarantine inspectors from Michigan, Illinois, etc.

D - Special stress on photos illustrating field conditions, field experiments, machinery operations and similar phases of the work.

E - Continuation of studies to determine the duration of the period of disintergration of cornstalks when plowed under in sandy or heavy soils, with reference to the period wherein such plowed-under material will afford adequate shelter to migrating borers in instances where the cornstalk residues are again brought to the soil surface by subsequent plowing.

F - Plots of miscellaneous field and truck crops to determine their possible infestation by P. nubilalis.

IV - Parasites and p[illegible]s.

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TENTATIVE PROGRAM AND PLAN FOR CORN BORER INVESTIGATIONS. TOLEDO, OHIO. (1928)

I - Control (co-operation with engineers, agronomists, etc.)
- A - Plowing infested material.
  - 1 - Field observations, Check effectiveness of fall and spring plowing, under farm conditions, following standard method of debris examination. Special stress upon fields where larval population was determined in standing stalks or stubble before treatment. Compute percentage of control achieved, based upon larval population before and after treatment.
    - a - Special observations upon status of weeds, grasses, trash, etc., along fence-row or field margin, of fields where infested cornstalks were plowed under.
- B - Burning infested material.
  - 1 - Check effectiveness of burning, under farm conditions, or with special burning machines. (See section I - E also)
- C - Check effectiveness of various other methods of mechanical control (i.e. - poled, raked, burned and disked; poled, raked, burned and plowed; stubble fields disked without previous treatment; standing stalks plowed with, or without, previous treatment; stubble fields plowed with, or without, previous treatment; etc., etc., as in preceding years.
  - 1 - Compute larval population per acre, by standard debris examination, as in I - A - 1.
- D - Check effectiveness of special machinery.
  - 1 - Stubble pulverizer.
  - 2 - Burning machines.
  - 3 - Low-cutting devices
  - 4 - Husker - shredders.
  - 5 - Ensilage cutters, etc., etc., etc.
- E - Heating and combustion tests.

  Note: Subject to revision as investigation proceeds.
  - 1 - Free larvae.
    - a - Construct curve showing time period and temperature required to kill free larvae. If possible, repeat this under different percentages of relative humidity in the oven, viz., sub-normal (approximately 40%), normal (approximately 70%) and above normal (approximately 85-90%).
      - (1) - Start at 150° F. for 5 minutes - 3 lots of 25 larvae in each lot (triplicate). If complete mortality is secured in all 3 lots, reduce time period and repeat tests (at 4½ minutes, then 4 minutes, 3½, 3, 2½, 2, 1½, 1, 30 seconds, 15 seconds, 5 seconds and 2 seconds), until a point is reached where a large percentage of larvae consistently survive. If complete mortality is not secured in 5 minutes, increase the time period at 1/2 minute intervals until a complete mortality is secured in all three lots.

TENTATIVE PROGRAM AND PLAN FOR [illegible] SOREER

INVESTIGATIONS. TOLEDO [illegible] (1928)

I - Control (co-operation with [illegible], etc.)
A - Plowing infested material.
1 - Field observations. Check effectiveness of fall and spring plowing, under farm conditions, following standard method of debris-examination. Special areas upon fields where larval population was determined in standing stalks or stubble before treatment. Compare percentage of control achieved, based upon larval population before and after treatment.
a - Special observations upon stalks of weeds, grasses, trash, etc., along fence-row of field margin, of fields where infested cornstalks were plowed under.
B - Burning infested material.
1 - Check effect [illegible] of burning, under farm conditions, or with special burning machines. (See section I - E also)
C - Check effectiveness of various other methods of mechanical control (i.e. - poled, raked, burned and diaked; poled, raked, burned and plowed; stubble fields diaked without previous treatment; standing stalks plowed with, or without, previous treatment; stubble fields plowed with, or without, previous treatment; etc., etc., as in preceding years.
1 - Compute larval population per acre, by standard debris examination, as in I - A - 1.
D - Check efficiency of special machinery.
1 - [illegible] pulverizer.
- Burning machines.
- Low-cutting devices.
- Shaker - gatherers.
- Emplage cutters, etc., etc., etc.
- Heating and combustion [illegible]ts.
Note: Subject to variation as investigation proceeds.
II - Free larvae.
A - Construct curve showing time period [illegible] temperature required to kill free larvae. If possible, repeat this under different percentages of relative humidity in the oven, viz., sub-normal (approximately 40%), normal (approximately [illegible]%) and above normal (approximately 85-90%).
(1) - Start at 140° F. for 5 minutes - 5 lots [illegible] in each lot (triplicate). If complete mortality is secured in all 5 lots, reduce time period and repeat [illegible] (at 4½ minutes, then 4 minutes, 3½, 3, 2½, 2, 1½, 1, 30 seconds, 15 seconds, 5 seconds and 2 seconds) until a point is reached where a [illegible] percentage of larvae [illegible] survive. If [illegible] complete [illegible] is not secured in 5 minutes, increase the time period [illegible]

Repeat at 155° F., and at 5° intervals, until a point is reached where a consistent kill is secured in exposures not exceeding 2 seconds. When this desired point is reached, a further refinement of the 5° interval should be attempted. For example, if all larvae are killed consistently at a temperature of 205° F. for 2 seconds, and a few survive at 200° F. for 2 seconds, a special series should be conducted at 201°, 202°, 203°, 204°, if the apparatus permits such refinements.

(2) - For tests under 1 - a - (1), it is desirable to use larvae taken from the following environments:

(a) - From outdoor temperatures ranging from approximately 0° to 50° F., at 10° intervals.

(b) - From indoor temperatures, of 24 hours duration, ranging from 50° to 70° F., at 10° intefvals.

(c) - From cornstalks containing various amounts of moisture (1%, 5%, 10%, etc.). Include experiments with saturated stalks.

(d) - Reverse process from high to low temperatures if possible.

(3) - Retain all larvae which are not patently beyond recovery, for a period of at least 2 weeks, to determine whether the heating has induced any latent effects. Place them in copper screen cans with folded newspaper. Keep cans in a temperature ranging from 50 - 70° F. and soak at intervals of 2 or 3 days to provide contact moisture. Keep a check, under same conditions, composed of larvae cut from untreated cornstalks.

(4) - Same special cage (or basket) must be devised to keep the larvae from coming into direct contact with the sides of the oven. Possibly such cage or basket can be constructed of gauze or 20-mesh copper screen or asbestos flour. Good success has been secured with a small cage made of cheese cloth and small wooden strips, but at high temperatures this arrangement would probably not prove satisfactory. The solution of this point will require experimentation.

(5) - Develop arrangements to introduce material into oven without appreciable lowering of temperature. Otherwise the time period must be computed from the point when oven reaches the desired temperature. This latter involves a serious inaccuracy owing to accumulated temperature units.

2 - Larvae in Cornstalks.

a - Construct curve showing time period and temperature required to kill larvae within cornstalks. If possible, repeat this under different humidity conditions as detailed under 1 - a.

(1) - Start at 1000° F., and increase at 100° intervals, until a point is reached where a consistent kill is secured in exposures not exceeding 2 seconds. Use 3 lots of 10 infested cornstalks in each test. When this desired point is reached, a further refinement of the 100° interval should be attempted. For example, if all larvae are killed consistently at a temperature of 1600° F. for 2 seconds, but a few survive at a temperature of 1500° F. for 2 seconds, a special series should be conducted at 1550°, etc., if the apparatus permits such refinement.

(2) - Same as 1 - a - (2).

(3) - Same as 1 - a - (3).

(4) - Install thermo-couple to obtain reading attained in center of stalks in all tests. Probably the most desirable method will be to include thermocouples in infested, as well as non-infested cornstalks, in each test, or to conduct a special test to determine whether any variation exists in the penetration of heat in infested and non-infested cornstalks. If a special test of this kind shows little, if any difference between heat penetration in infested and non-infested stalks, it may prove unnecessary to include non-infested stalks in the main experiments of this series.

(5) - Same as 1 - a - (5).

3 - Special Experiments With Infested Cornstalk sections.

a - When temperature and moisture requirement for insuring 100% larval mortality for 2 seconds exposure have been ascertained, test different parts of corn plant to determine possible variations in reaction due to size or composition of different portions of the stalk.

(1) - Three lots of 25 infested corn stalk sections per lot (triplicate), from upper third, from middle third and from lower third of stalk. Include 8-inch stubble, 3 lots, with as many stubble per lot as can be handled by oven.

b -Transfer directly 3 lots, of 25 infested cornstalk sections per lot, from outdoor temperatures of 10°, 20°, 30°, 40° F., to immediate indoor temperatures of 1000°, 1500°, F., etc., for 2 seconds. Use cornstalks with various moisture content as in 1 - a - (2) - (c).

c - The reverse of preceding series. Transfer directly 3 lots, of 25 infested cornstalk sections per lot, from indoor temperatures of 50°, 80°, 100°, and 150° for 5 minute exposures and at 1000° and 1500° F. for an exposure just short of killing point, to outdoor temperatures of 10°, 20°, 30°, and 40° F.

(1) - Same as 3 - b - (1).

d - Compare fatal temperatures and time period of larvae contained in succulent green cornstalks (natural moisture) with mortality of larvae contained in cornstalks which have dried out as a feature of maturity but have become saturated or nearly so, with moisture from direct precipitation, or other sources. (Green cornstalks from center of large shocks at Monroe cage or elsewhere).

e - During progress of tests with cornstalk sections, insert small thermometer, so that bulb registers temperature at the center of the stalk. Remove stalk section at end of time period. Note temperature when stalk section was removed and note whether temperature increases or decreases and the rate of such increase or decrease, at 5 or 10 second intervals.

f - Simulate, if possible, the effect of heat dilution or movement, when the field burner is subjected to high winds, thus causing much of the heat to be blown away from the cornstalks, or other plant material, toward which it is directed.

4 - When the most effective and practical killing temperature has been determined, construct a melting "plug" or "cone" designed to be inserted in cornstalks in the field and to melt or otherwise verify when proper temperatures are being attained by burning outfits.

II-Proposed Projects for Toledo Demonstration and Development Farm. (co-operation with engineers, agronomists, etc.).

A - Demonstration and test of various clean-up measures, in 5-acre unit farms, where a two-year rotation will be practiced, and the entire area kept covered with screen during the period the moths are in flight. Treatment of separate unit areas to be as follows:

1 - Poled, raked and burned.
2 - Standing stalks plowed, in fall or spring.
3 - Stubble plowed, in fall or spring.
4 - Stalks cut low, removed from field, followed by disking.
5 - Check - no adequate control. Stalks or high stubble disked to small grain, without previous treatment.
6 - Parasites alone - no other adequate control.

B - Machinery tests.

C - Varietal and seasonal planting tests.

D - Emergence of moths from barnyard and manure - pile conditions, duplicating conditions found on average farm.

E - Continuation of silo tests as a factor in corn borer control.

F - Demonstration of effectiveness of <u>clean</u> plowing.

1 - Erect screen cage over 1 acre plot of infested cornstalk land, plowed cleanly in fall of 1927. Larval expectancy computed in area before plowing. Cage to be placed in position at time of moth emergence and examination made daily

to determine number of moths emerging from area. Compute percentage of original borer population emerging as moths.

2 - Same for 1 acre plowed cleanly in the spring of 1928.

G - Co-operative corn testing project with University of Illinois.

1 - Three or four varieties of field corn each from northern Illinois, central Illinois and southern Illinois. (varieties to be selected by Holbert & Dungan).

2 - Two or three varieties of canner's sweet corn.

3 - Selfed and hybrid strains, F_1, F_2, and F_3, including diseased and disease-free varieties. (Selected by Holbert and Dungan).

4 - Varieties to be planted on two different planting dates. The first date of planting to be at the beginning of the normal planting season. The second date of planting to be 10 days later.

5 - Proposed rotation to be Corn, Soy Beans, and Wheat planted with Sweet Clover. Dr. Dungan and Dr. Bauer will recommend matters in connection with soil conditions).

H - Miscellaneous cultural experiments involving the development of farm practice to bring about clean cultural methods, under corn borer conditions, with due regard to expense involved and general practicability.

I - Insecticide Tests.

1 - Demonstration and test of the more promising insecticides, developed during detailed experiments at the Arlington, Mass. and Monroe, Mich. laboratories:

J - Parasite test on egg parasite.

1 - Field test of the practicability of rearing and liberating the egg-parasite T. minutum, with subsequent observation of the distance and velocity of dispersion and percentage of egg-parasitism.

K - Training of field scouts, infestation survey crews, etc.